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PATH ANALYSIS FOR QUALITY COMPONENTS IN LINSEED (*LINUM USITATISSIMUM* L.)

M. RAI,* S. A. KERKHI, P. A. NAQVI, S. PANDEY AND A. K. VASHISHTHA

Linseed Coordinating Unit, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur & Harcourt Butler Technological Institute, Kanpur 208002

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ABSTRACT

Path analysis for eight quality components was worked out in 22 linseed varieties tested in two fertility conditions. Statistical analysis was done in four ways: (a) oil dependent and other contributing characters, (b) protein dependent and other contributing traits, (c) iodine dependent and other contributing attributes, and (d) linolenic acid dependent and other contributing fatty acids. In the path analysis of oil content, linolenic acid had a high positive direct effect on oil content while protein content and iodine value exerted strong negative direct effects on oil content under normal fertility level. Under low fertility conditions, all the contributing traits had a direct negative effect on oil. Similar pattern was also observed in the path analysis of protein content. High positive effect of linolenic acid, followed by linoleic acid and saponification value, on iodine value was observed. Stearic and oleic acids affected directly and indirectly via other acids in negative way to the linolenic acid. Under both the fertility levels, five fatty acids showed similar relationship.

Key words: Path analysis, contributing traits, saponification.

Linseed has been one of the principal agroindustrial oilseed crops of India. Quality components like oil, protein and fatty acid profile are important while choosing the linseed products for different agro-based industries. Linseed oil with high percentage of unsaturated fatty acids is mainly used in the paint and varnish industries. High protein content of its cake makes it a very good concentrate for milch cattle.

The oil content and its quality in linseed is a complex entity influenced by various components. Although association of different components of seed and oil in linseed are studied by Naqvi and co-workers [1] but no information is available as to how these traits act under different fertility conditions under which the crop is cultivated. The present

*Present address: Assistant Director General (Seeds), I.C.A.R., Krishi Bhavan, New Delhi 110 001.

investigation, therefore, aims at analysing the extent and nature of direct and indirect effects of quality components among themselves under optimum and low fertility conditions.

MATERIALS AND METHODS

The experimental material comprised 22 linseed varieties, namely, Neelum, K-2, R-7, Neela, Sweta, Shubhra, LC-54, R-17, C-429, S-36, T 397, Jawahar-23, Pusa-2, Pusa-3, Mukta, JLS(J)-1, LC 185, R-552, Hira, Garima, Himalini and Chambal. These varieties were grown in completely randomized block design with three replications in a plot 3 x 5 m size under two fertility conditions: 60 : 30 : 30 (normal), and 30 : 15 : 15 kg NPK/ha (low). After harvesting replicationwise, seed samples from each entry were crushed in pestle and mortar. The crushed samples in duplicate were used for oil analysis by Soxhlet apparatus. Oil extracted cake was used for protein analysis by micro-Kjeldahl method. Fatty acid composition was determined by transesterification and gas-liquid chromatographic procedures. The data on oil content, protein content, iodine value, saponification value, palmitic, stearic, oleic, linoleic and linolenic acids were subjected to genotypic path coefficient analysis following the method given by Dewey and Lu [2] in the following four ways:

(a) Oil content dependent and rest of the traits as contributing

(b) Protein content dependent and rest of the characters as contributing

(c) Iodine value dependent and rest of the attributes as contributing

(d) Linolenic acid dependent and palmitic, oleic, stearic and linoleic acids as contributing

RESULTS AND DISCUSSION

Path coefficient analysis of oil content and its contributing traits (Table 1) revealed that linolenic acid and linoleic acid had a high and medium positive direct effect on oil content but protein level and iodine value had strong direct negative effects on oil under optimum fertility level. Linolenic acid had no association with oil content. This may be due to the fact that the high direct positive effect of linolenic acid on oil was neutralised by the indirect negative response of iodine value and linoleic acid. On the other hand, linoleic acid showed a weak negative association with oil content. This may be due to indirect negative effects of linolenic acid.

The protein content also showed strong negative association with oil content. This may be due to the negative contribution of all other traits except linoleic acid to oil content. There is little chance to break this strong negative association ($r = -0.97$) between oil and protein content by improving any component except linoleic acid which itself showed limited scope. However, as fibre content of seed is also an important constituent of seed, it would be

Table 1. Direct (in parentheses) and indirect effects of various quality components on oil content in linseed

Character	Fertility level	Effect via								Genotypic correlation with oil content
		protein content	iodine value	saponification value	palmitic acid	stearic acid	oleic acid	linoleic acid	linolenic acid	
Protein content	Optimum	(-0.75)	-0.02	-0.15	-0.06	-0.01	-0.03	0.07	-0.04	-0.97
	Low	(-0.65)	-0.30	-0.05	0.80	0.13	-0.85	0.13	-0.17	-0.95
Iodine value	Optimum	-0.20	(-0.67)	0.10	-0.11	-0.03	0.19	-0.16	0.68	-0.01
	Low	-0.03	(-6.31)	-0.08	0.35	3.98	9.33	-0.18	-7.16	-0.10
Saponification value	Optimum	0.40	-0.24	(0.28)	-0.44	0.00	0.08	-0.16	0.32	0.63
	Low	-0.75	-1.21	(-0.40)	0.65	0.13	4.45	-3.09	-0.57	-0.11
Palmitic acid	Optimum	0.22	0.36	-0.06	(0.20)	0.01	-0.12	-0.03	-0.31	0.27
	Low	0.38	1.57	0.18	(-1.39	-0.55	-1.82	1.11	1.32	0.80
Stearic acid	Optimum	0.16	0.60	-0.01	0.05	(0.03)	-0.15	0.10	-0.54	0.24
	Low	0.02	5.43	0.01	-0.17	(-4.63)	-6.49	-0.32	6.10	0.01
Oleic acid	Optimum	0.09	0.62	-0.11	0.01	0.02	(-0.21)	0.11	-0.64	-0.18
	Low	-0.05	5.67	0.17	-0.24	-2.87	(-10.39)	1.60	6.06	-0.05
Linoleic acid	Optimum	-0.14	0.30	-0.13	-0.02	0.01	-0.07	(0.35)	-0.49	-0.19
	Low	0.02	-0.24	-0.26	0.33	-0.32	3.54	(-4.70)	1.62	-0.01
Linolenic acid	Optimum	0.04	-0.64	0.12	-0.09	-0.02	0.19	-0.24	(0.72)	0.08
	Low	-0.02	-6.06	-0.03	0.25	3.79	8.45	1.02	(-7.45)	-0.05

Residual values: Optimum - 0.0009, low - 0.0530.

worthwhile to examine the possibility of improving protein and oil content simultaneously to an optimum level depending on the requirement at a time scale at the cost of the fibre content.

No consistent results were obtained between two soil fertility levels with regard to direct effects of the traits on oil content except protein content. Under low fertility, all the contributing traits had a direct negative effect on oil content. However, oleic acid followed by linolenic acid and iodine value exhibited the highest negative direct effect on oil without strong association with oil. This may be due to a strong indirect positive influence via traits like iodine value and, linoleic acid in the case of oleic acid, and via oleic and stearic acids in case of linolenic acid and iodine value.

Path analysis of protein content and its contributing traits (Table 2) showed similar pattern as for oil content under both the fertility conditions.

Table 2. Direct (in parentheses) and indirect effects of various quality components on seed protein content in linseed

Character	Fertility level	Effect via								Genotypic correlation with protein content
		oil content	iodine value	saponification value	palmitic acid	stearic acid	oleic acid	linoleic acid	linolenic acid	
Oil content	Optimum	(-1.34)	0.01	0.24	0.08	0.01	0.04	-0.10	0.09	-0.97
	Low	(-1.98)	1.54	0.12	-2.79	-0.14	1.26	0.11	0.94	-0.95
Iodine value	Optimum	0.01	(-0.92)	0.13	-0.15	-0.05	0.21	-0.23	1.02	0.03
	Low	0.20	(-15.48)	-0.21	0.87	9.77	23.14	-0.44	-17.81	0.05
Saponification value	Optimum	-0.85	-0.32	(0.38)	-0.06	0.00	0.09	-0.24	0.48	-0.53
	Low	0.22	-2.97	(-1.09)	1.63	0.31	11.05	-7.63	-1.41	-0.12
Palmitic acid	Optimum	-0.36	0.49	-0.08	(0.29)	0.01	-0.13	-0.04	-0.48	-0.29
	Low	-1.58	3.84	0.51	(-3.51)	-1.35	-4.51	2.75	3.28	-0.58
Stearic acid	Optimum	-0.33	0.82	-0.01	0.08	(0.05)	-0.16	0.16	-0.82	-0.21
	Low	-0.03	13.33	0.03	-0.42	(-11.35)	-15.98	-0.80	15.19	0.03
Oleic acid	Optimum	0.24	0.85	-0.15	0.16	0.04	(-0.22)	0.17	-0.97	0.12
	Low	0.10	13.90	0.47	-0.62	-7.04	(-25.77)	3.96	15.09	0.08
Linoleic acid	Optimum	0.25	0.40	-0.17	-0.02	0.02	-0.07	(0.53)	-0.74	0.19
	Low	0.02	-0.58	-0.71	0.83	-0.78	8.78	(-11.62)	4.04	-0.03
Linolenic acid	Optimum	-0.11	-0.87	-0.17	0.13	-0.04	-0.20	0.36	(1.08)	-0.06
	Low	0.10	-14.87	-0.08	0.62	9.30	20.97	2.53	(-18.54)	0.02

Residual values: Optimum - 0.0016, low - 0.1618.

The analysis of direct and indirect effects of the contributing traits on iodine value (Table 3) exhibited the highest positive effect of linolenic acid, followed by linoleic acid and saponification value under optimum fertility level. Similar positive association was also recorded by Singh [3] in her studies with parents and F_1s. Linolenic acid also has strong association with iodine value, indicating that the degree of unsaturation of linseed oil is largely due to the presence of high percentage of linolenic acid in oil. However, under low fertility level, the highest direct negative effect was observed for linolenic acid, but it was neutralized due to indirect effects of oleic and stearic acids which resulted in a high positive association of linolenic acid with iodine value. High direct negative effect of oleic acid and direct as well as indirect effects of stearic acid via oleic acid resulted in the strong negative associations of these traits with iodine value.

Table 3. Direct (in parentheses) and indirect effect of various quality components on iodine value in linseed

Character	Fertility level	Effect via								Genotypic correlation with iodine value
		oil content	iodine value	saponification value	palmitic acid	stearic acid	oleic acid	linoleic acid	linolenic acid	
Oil content	Optimum	(-1.17)	0.87	0.22	0.06	-0.01	0.04	-0.09	0.09	-0.01
	Low	(-0.58)	0.44	-0.01	-0.70	-0.03	0.34	0.04	0.40	-0.10
Iodine value	Optimum	1.14	(-0.89)	-0.18	-0.06	0.01	-0.03	0.09	-0.06	-0.02
	Low	0.55	(-0.46)	0.01	0.51	0.08	-0.56	0.12	-0.18	0.05
Saponification value	Optimum	-0.74	0.47	(0.34)	0.05	0.00	0.08	-0.22	0.47	0.35
	Low	0.06	-0.05	(0.05)	0.41	0.07	2.94	-2.63	-0.60	0.19
Palmitic acid	Optimum	-0.32	0.26	-0.08	(0.22)	-0.01	-0.11	-0.04	-0.46	-0.54
	Low	-0.46	0.27	-0.02	(-0.87)	-0.32	-1.20	0.97	1.39	-0.25
Stearic acid	Optimum	-0.29	0.19	-0.01	0.06	(-0.04)	-0.14	0.14	-0.79	-0.89
	Low	-0.01	0.01	0.00	-0.10	(-2.69)	-4.25	-0.28	6.45	-0.86
Oleic acid	Optimum	0.21	-0.11	-0.14	0.12	-0.03	(-0.20)	0.16	-0.94	-0.93
	Low	0.03	-0.04	-0.02	-0.15	-1.67	(-6.85)	1.39	6.41	-0.90
Linoleic acid	Optimum	0.22	-0.17	-0.16	-0.12	-0.01	-0.07	(0.48)	-0.72	-0.44
	Low	0.01	0.01	0.03	0.21	-0.19	2.33	(-4.04)	1.72	0.04
Linolenic acid	Optimum	-0.10	0.05	0.15	-0.10	0.03	0.18	-0.33	(1.05)	0.95
	Low	0.03	-0.01	0.00	0.15	2.21	5.57	0.89	(-7.88)	0.96

Residual values: Optimum - 0.0015, low - 0.0043.

The analysis of the relationship between 5 fatty acids of linseed oil (Table 4) showed that stearic acid and oleic acid had direct and indirect negative effects on linolenic acid via other acids. These negative effects may be responsible for the strong negative association of these acids with linolenic acid under both the fertility levels. All the fatty acids had direct negative association with linolenic acid. Such an association would be useful in breeding varieties for edible and industrial purposes, separately.

In the present investigation, in general, no consistent difference in the behaviour of different traits was observed under the two fertility levels except in the case of five fatty acids and their mutual correlation. It indicated that change in environment has a great role in affecting the relationship among the quality components of the linseed crop. Hence, in contemplating selection strategy for the improvement of the crop with respect to quality traits, likely crop growing situation be kept in view.

Table 4. Direct (in parentheses) and indirect effects of different fatty acids on linolenic acid content of linseed oil

Character	Fertility level	Effect via				Genotypic correlation with linolenic acid
		palmitic acid	stearic acid	oleic acid	linoleic acid	
Palmitic acid	Optimum	(−0.13)	−0.06	−0.29	0.03	−0.44
	Low	(−0.12)	−0.03	−0.14	0.12	−0.18
Stearic acid	Optimum	−0.03	(−0.22)	−0.36	−0.14	−0.75
	Low	−0.02	(−0.28)	−0.49	−0.03	−0.82
Oleic acid	Optimum	−0.07	−0.16	(−0.51)	−0.15	−0.89
	Low	−0.02	−0.18	(−0.78)	0.17	−0.81
Linoleic acid	Optimum	0.01	−0.65	−0.16	(−0.47)	−0.69
	Low	0.03	−0.02	0.27	(−0.49)	−0.22

Residual values: Optimum − 0.0001, low − 0.001.

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